NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

NDIA

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

2003 USSOCOM Chemical, Biological, Radiological and Nuclear (CBRN) Conference & Exhibition

Update: Nanomaterials and Nanomanufacturing Center, University of South Florida

Michael G. Kovac, PhD

Director, NNRC
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USSOCOM Chemical, Biological, Radiological and Nuclear Conference and Exhibition

December 1-4, 2003

Topics

- USF: National / Regional Context
- USF Assets Related to Objectives of 2003 USSOCOM CBRN Conference
- Overview of Selected Research in Nanomaterials and Nanomanufacturing at USF

Topics

- **USF: National / Regional Context**
  - » **USF Factoids**
  - » **National High Tech Ranking**
  - » **High Tech Industries—"The Corridor"**
- USF Assets Related to Objectives of 2003 USSOCOM CBRN Conference
- Overview of Selected Research in Nanomaterials and Nanomanufacturing at USF

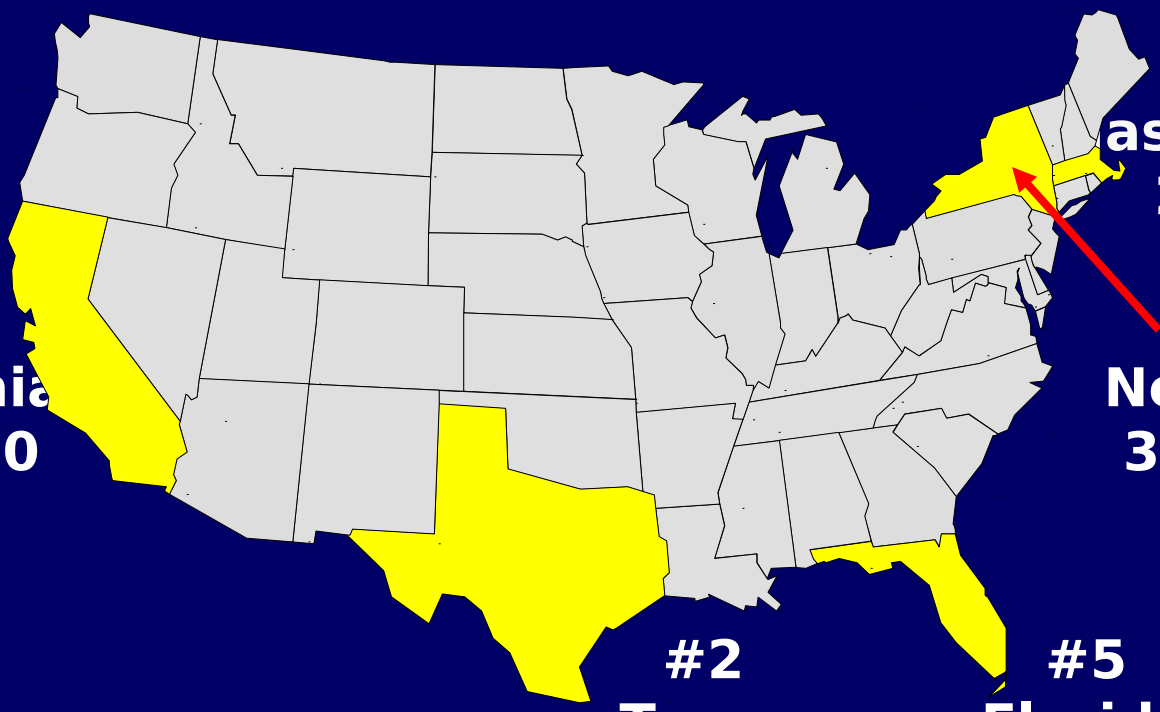
USF Factoids

- 40,000 students (all 50 states, 110 countries)
- Second largest in Southeast, top 20 in nation
- "**Research I**" designation by Carnegie Foundation
- Over $250 Million in sponsored research
- 11 Colleges (Engineering, Medicine, Arts and Sciences, Marine Science, Business….)
- Affiliated with 4 hospitals
- Moffitt Cancer Center
- R & D Park, Center for Entrepreneurship…

- In terms of High Tech Jobs….
  - Where does Florida rank???

Top Cyberstates By High-Tech Employment, 2000

U.S. High-Tech Employment = 5.3 million

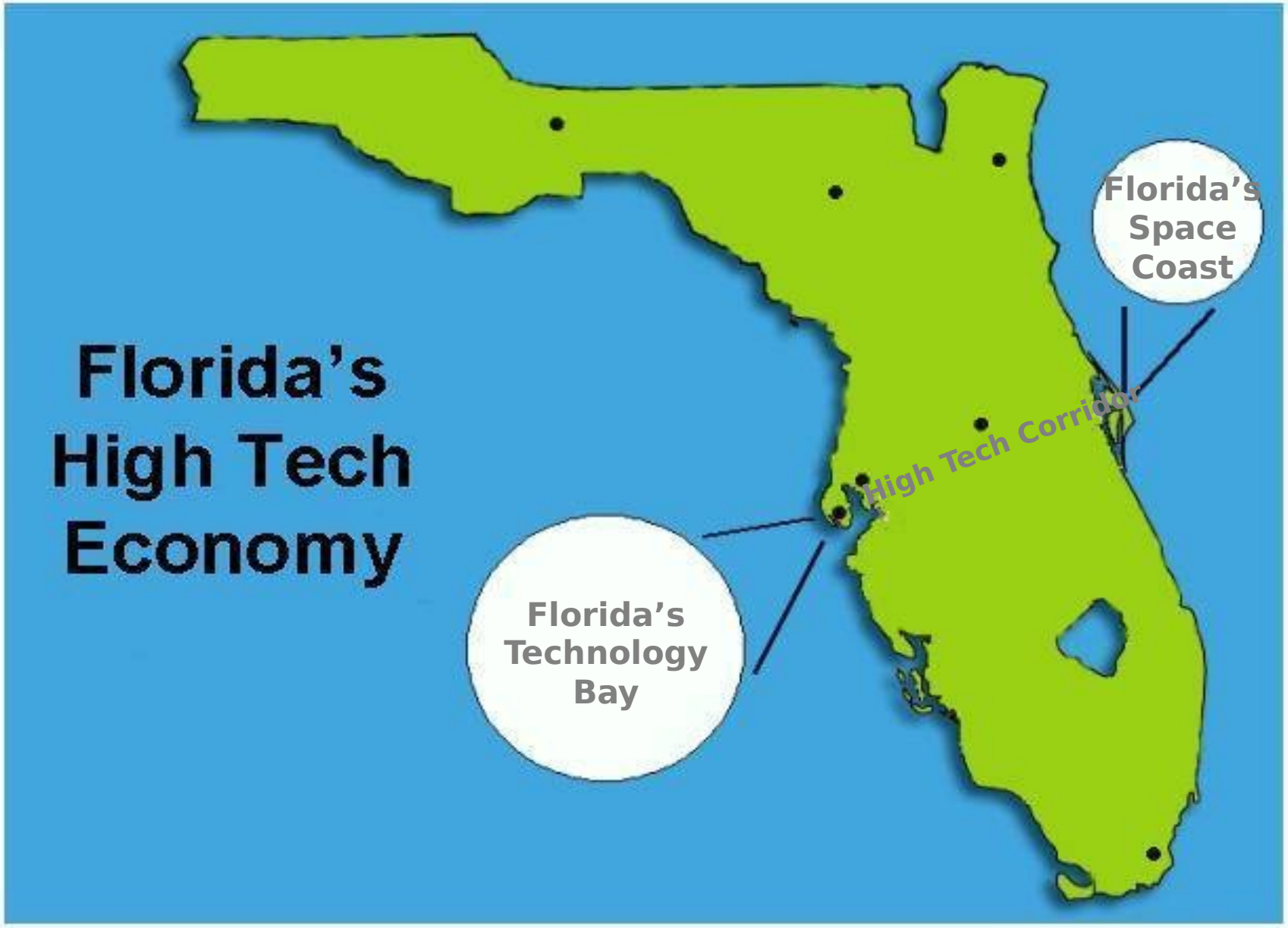


Source: Bureau of Labor Statistics

- Florida ranks 5th in the Nation in High Tech jobs……33% growth from 1994 to 2000 (AeA data)

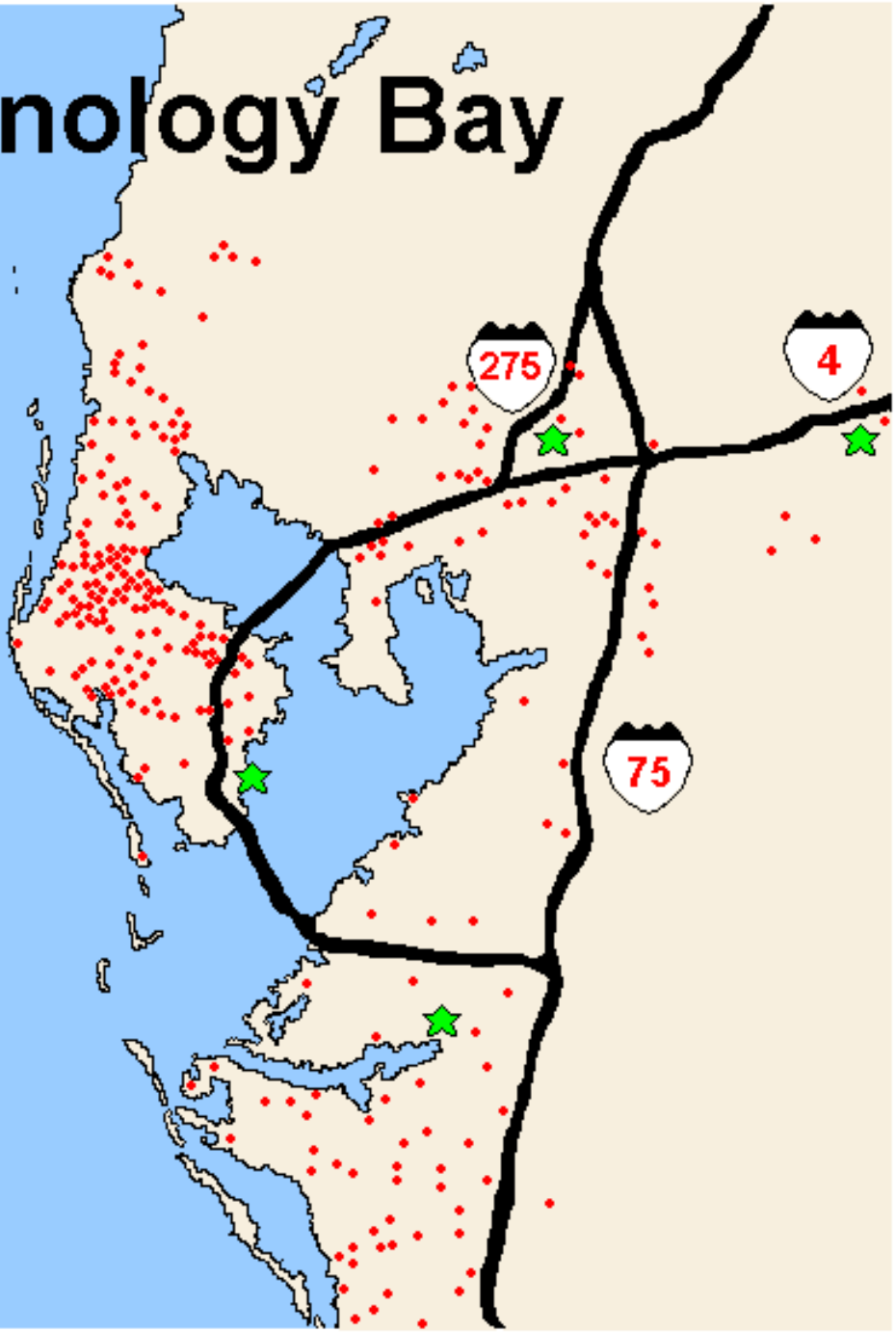
- 70% of the High Tech Jobs are in the “High Tech Corridor”

This satellite photograph taken at night clearly shows the High Tech Corridor running through central Florida.


Florida's High Tech Economy
Florida's Space Coast
High Tech Corridor
Florida's Technology Bay

Florida's Technology Bay

- Information Technologies
- Software Development
- Telecommunications
- Medical Products
- Medical Technologies
- Microelectronics
- Aerospace



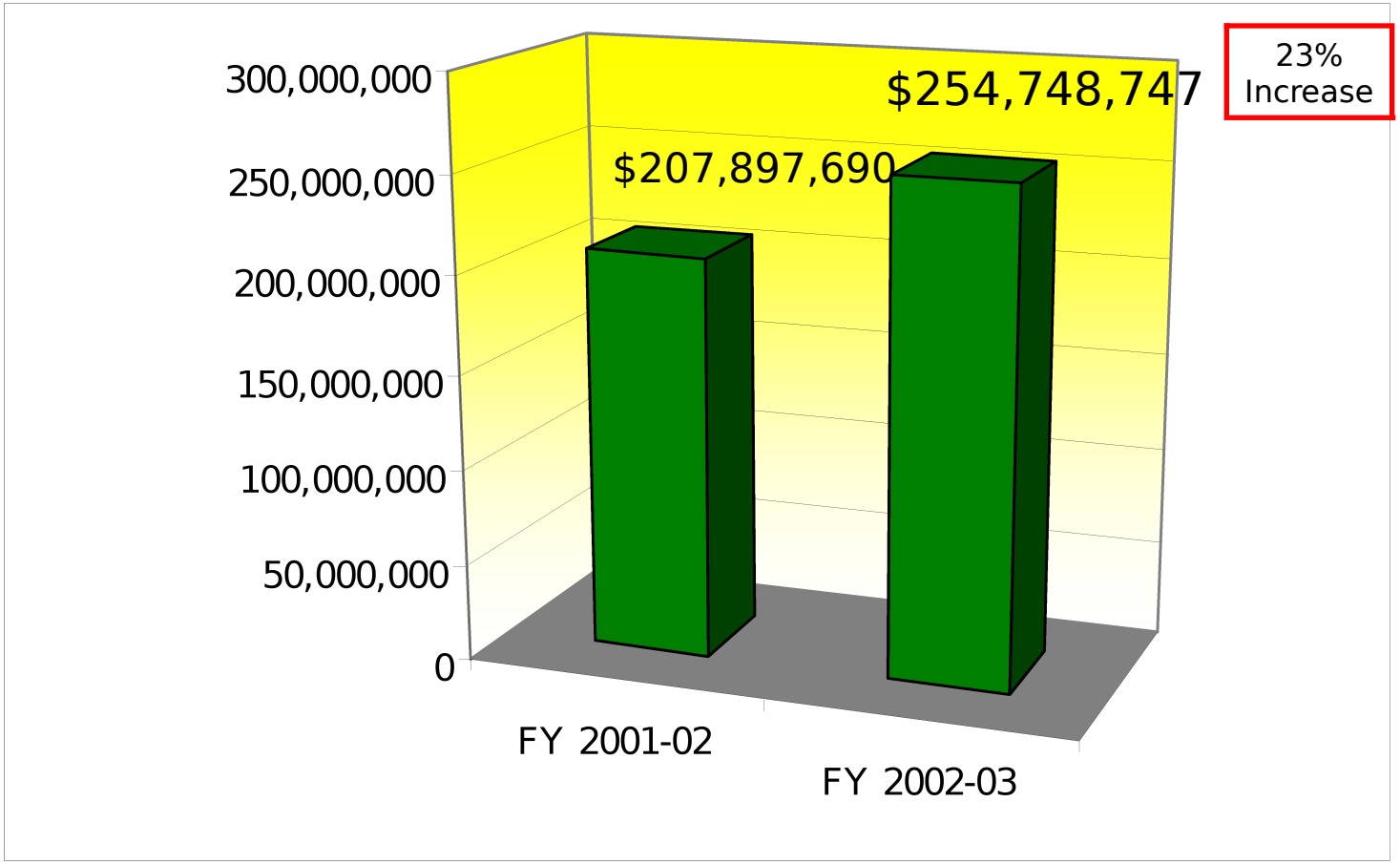
Topics

- USF: National / Regional Context

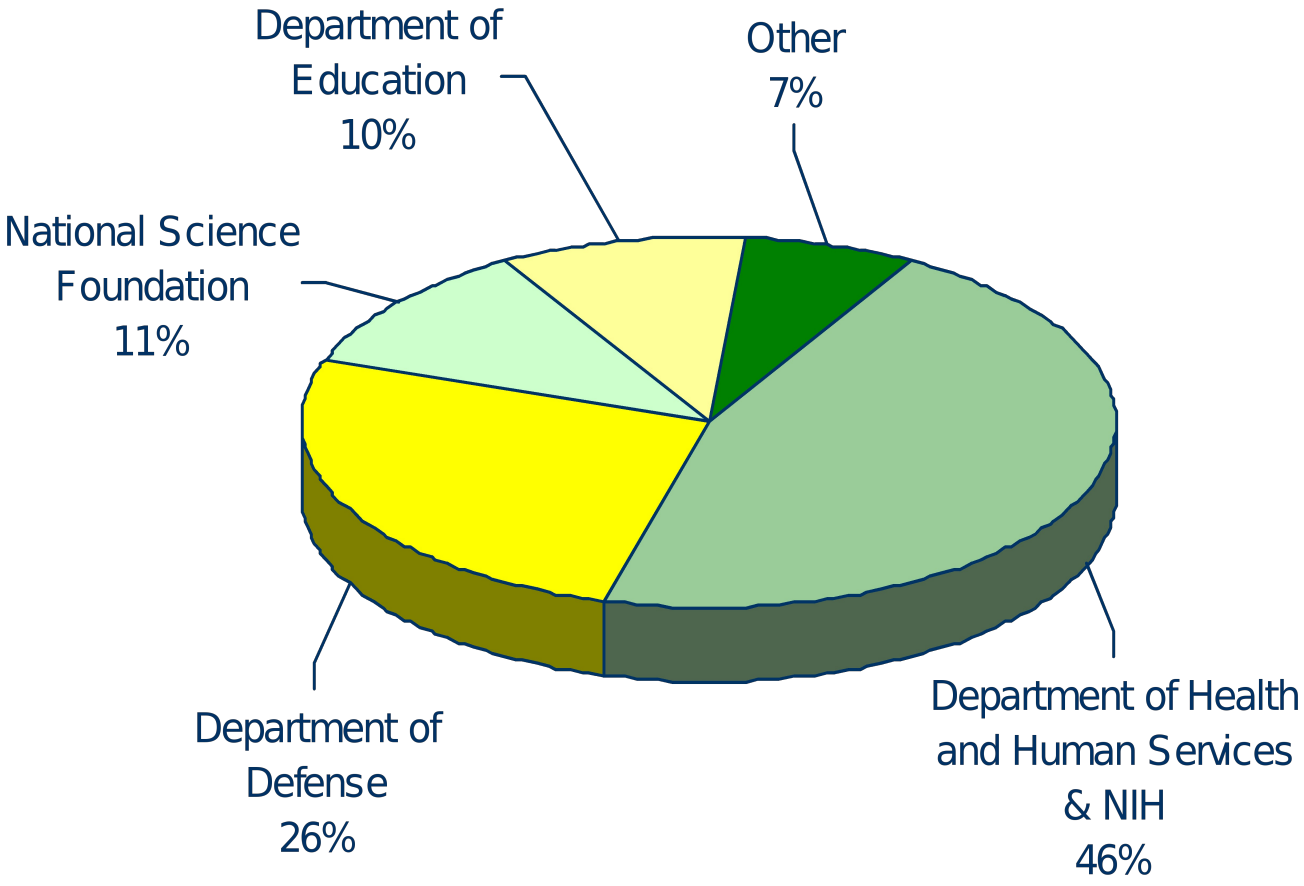
- USF Assets Related to Objectives of 2003 USSOCOM CBRN Conference
  - USF Research base
  - Colleges of Engineering, Arts and Science, Marine Science
  - Focused Centers of Excellence
  - New laboratories and research buildings

- Overview of Selected Research in Nanomaterials and Nanomanufacturing at USF

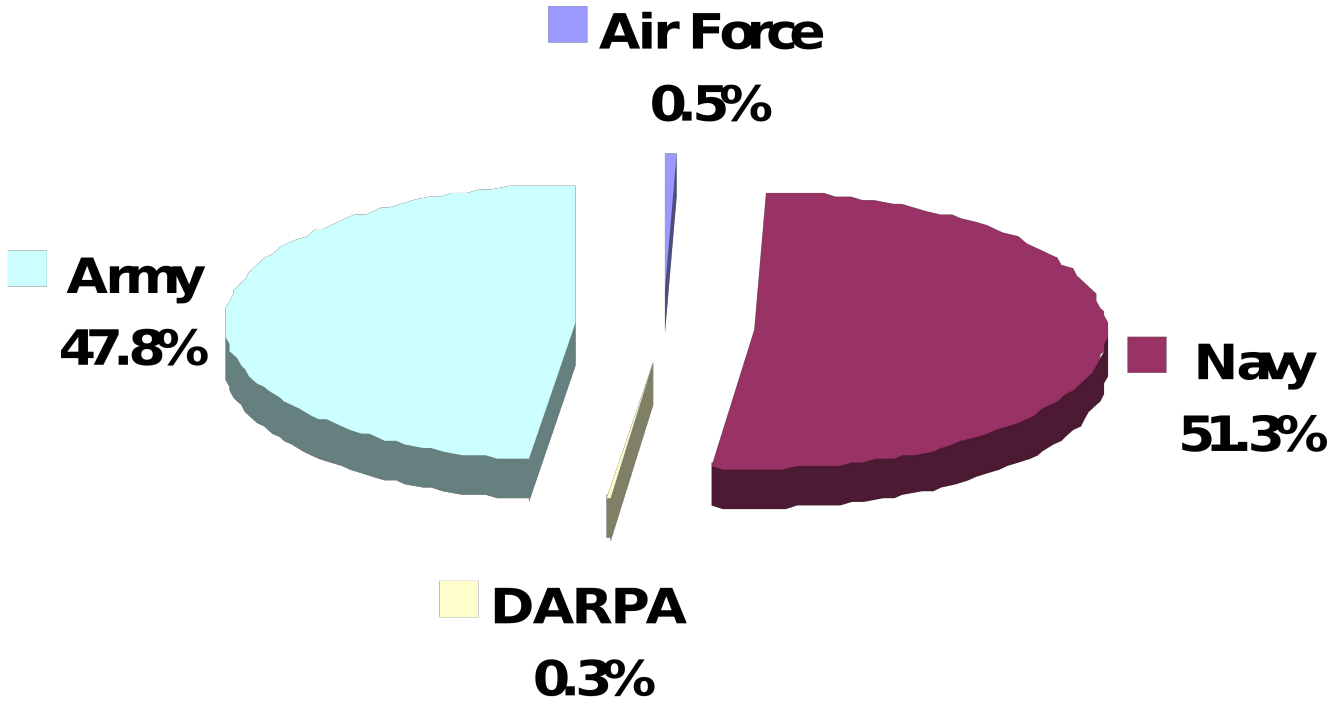
RESEARCH AWARD COMPARISON



Primary Sources of Federal Funding 2002/2003



Department of Defense Funding 2002/2003



Daniel Lim, Ph.D.
Professor of Biology

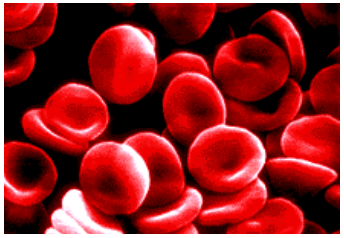
Advanced Bio-Sensors Group

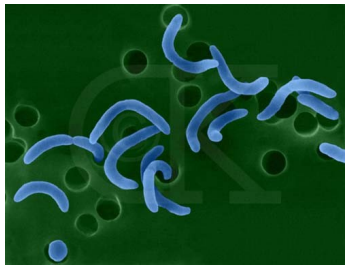
The primary focus of our research is the characterization of virulence mechanisms in pathogenic bacteria and development of innovative technology to rapidly detect and identify bacterial pathogens in food, water, air, surfaces, and infectious diseases

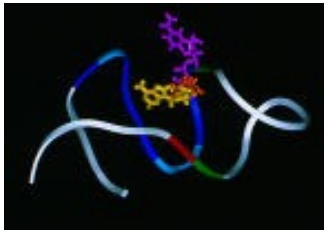
USF Biosensor Laboratory

Center for Biological Defense

- Assay development for integrating waveguide, array, and fiber optic (RAPTOR) biosensors
- Rapid, direct processing of complex matrix samples (food, blood, water)
- Recovery of live bacteria for viability determination, archiving, PCR, and confirmatory identification
- Multiple format capture molecules on a single platform - antibodies, nucleic acids, aptamers, cell receptors
- Portable, field-friendly platforms







Representative Analytes Detected by Biosensor Assay

- *Bacillus anthracis*
- *Bacillus globigii*
- *Vibrio cholerae*
- *Salmonella*
- *E. coli* O157:H7
- *Listeria*
- *Enterococcus*
- Vaccinia virus (smallpox)
- Ricin
- Cholera Toxin
- Botulinum Toxin
- SEB
- *Cryptosporidium*
- *Giardia*

Jacqueline Cattani, PhD
Director

Center for Biological Defense

USF Center for Biological Defense (Est. 2000): Response to Fall 2001 Anthrax attacks

- Sample preparation, spore inactivation, and molecular detection
- Molecular surveillance protocols (tracking)
- Rapid antimicrobial susceptibility
- New detection technologies

Threat assessment, sample collection, decontamination, and laboratory awareness training provided across Florida

Basic/Applied Research

Prototyping

Field Evaluation

Deployment

Training

CENTER FOR BIOLOGICAL DEFENSE USF

- New CBD technologies tested on "real" samples
- Evaluated surface and air decontamination devices
- Developed threat assessment and sample collection protocols for first responders

Activation and Response Team –Sample collection assistance for bomb squads and HazMat

Evaluation of over 2,000 "anthrax-like" samples conducted with partners (Florida Dept. of Health, FBI and CDC)

- Field testing of sample collection and decontamination procedures
- Sample preparation/ detection procedures tested by DOH personnel

Center for Biological Defense
University of South Florida

Laboratory

- Rapid detection, typing & characterization of BT agents
- Evaluation and validation of BT detection kits and field devices
- Development of devices and techniques for BT agent identification

Education

- Development and implementation of training programs and materials for first responders and the medical community
- Member of the Florida University Alliance for Weapons of Mass Destruction Education
- Acts as a resource on local, state, and national BT issues

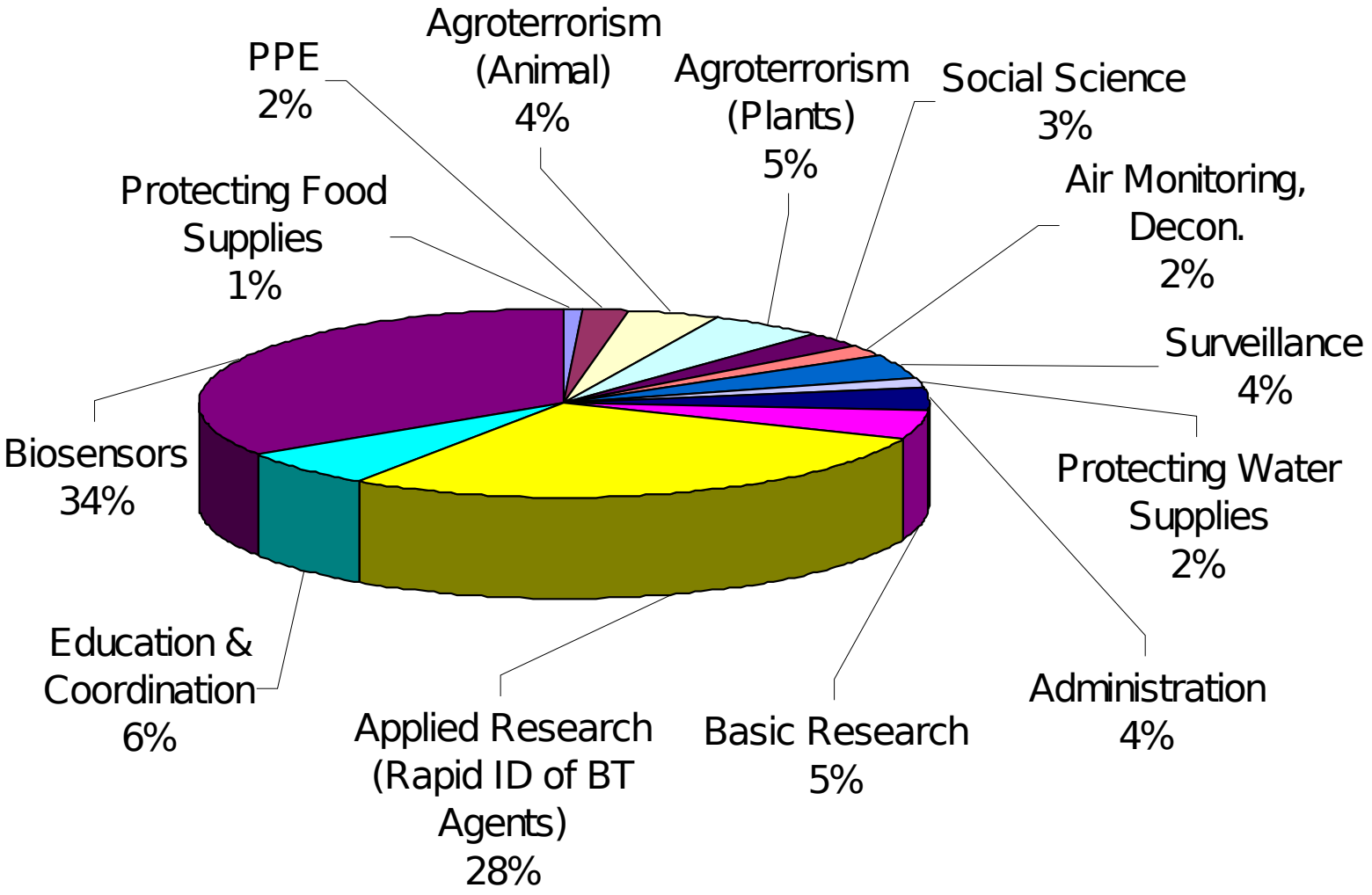
Surveillance

- Dual-use and web-based syndromic surveillance systems for the early detection of BT and infectious diseases
- Automatically analyzes data in real-time and compares to historical data for issuing automated alerts

Advanced Biosensors Group

- Development of technology that will affordably and precisely process multiple pathogens simultaneously
- Creation of near real-time BT detection field devices
- Production of transportable fiber optic, array, and integrating wave-guide biosensor systems to rapidly detect pathogens and toxins in food and water

FY 2002-2003 CBD Research Program



Underwater Communications:

Bottom Stationing Ocean Profiler (BSOP)

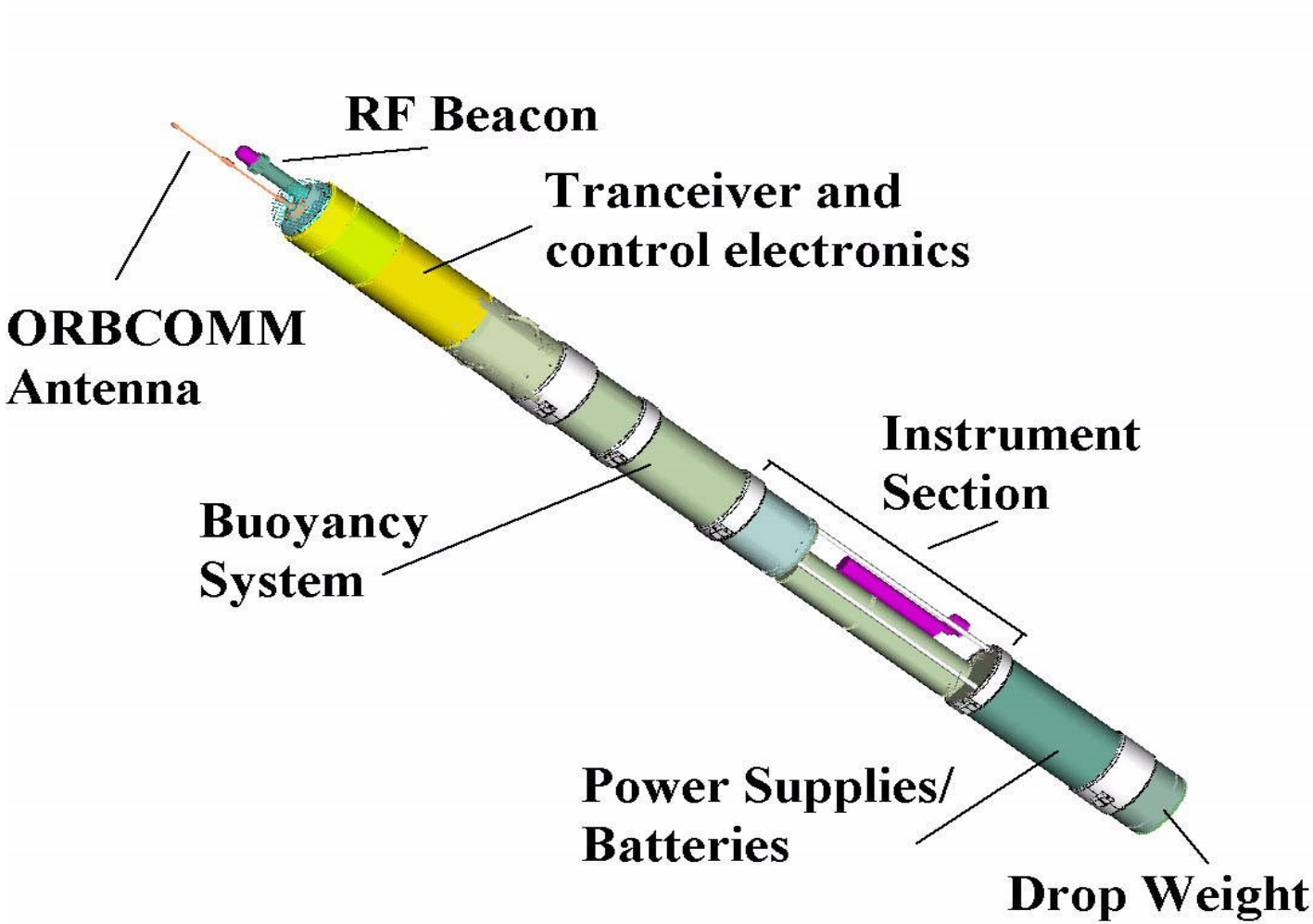
College of Marine Science

Larry Langebrake

Director

USF Center for Ocean Technology

BSOP Design


RF Beacon
Tranceiver and
control electronics
ORBCOMM
Antenna
Instrument
Section
Buoyancy
System
Power Supplies/
Batteries
Drop Weight

New Research Facilities

1. Business/Research Park
   Interdisciplinary Sciences Building
2. Nanotech Building
3. Biodefense Research Building (SCF)
4. Natural &Environmental Sciences
5. Science and Technology Building
   at St. Petersburg

Interdisciplinary Research Building

HDR | ONE COMPANY *Many Solutions™*

Nanotech1 , USF

west elevation

scale 1/8" = 1' 0"

NanoTech I Building

Topics

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College of Engineering Thrust Areas

- Bioengineering
- Nano (Materials,Technology,Manufacturing)
- Robotics and Sensor Technology
- Info & Communications Tech
- Critical Infrastructure
- Transportation Logistics
- Energy and Environmental Systems
- Advanced Materials Manufacturing
- Engineering the Service World
- Integration of Education and Research

Nanomaterials and Nanomanufacturing Research Center, NNRC

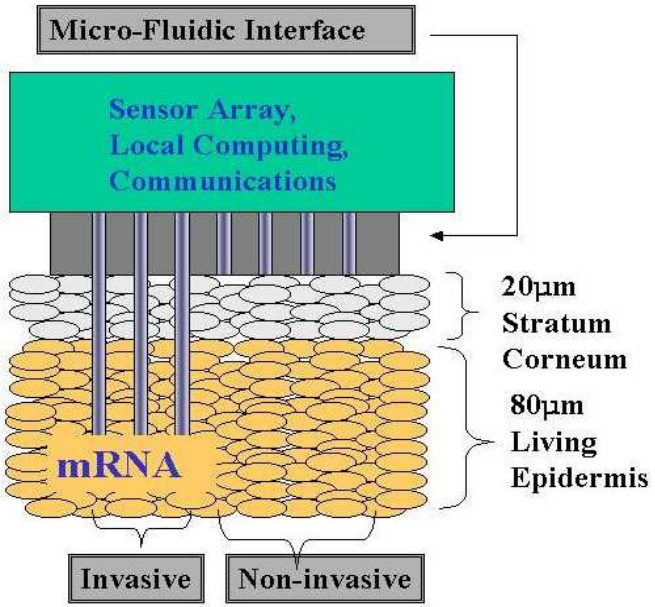
- NNRC Capabilities
  - People
  - Facilities
- Research Examples
- NNIN, National Nanotechnology Infrastructure Network

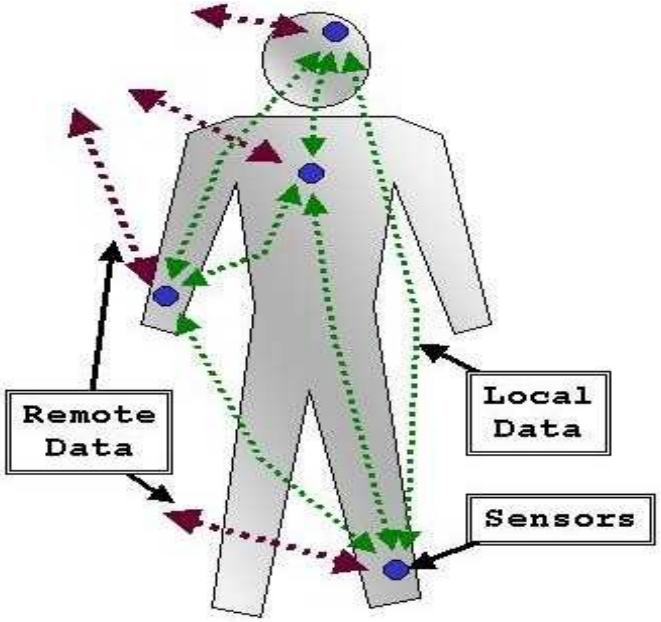
Shekhar Bhansali, PhD
Electrical Engineering

MEMS, Microsystems

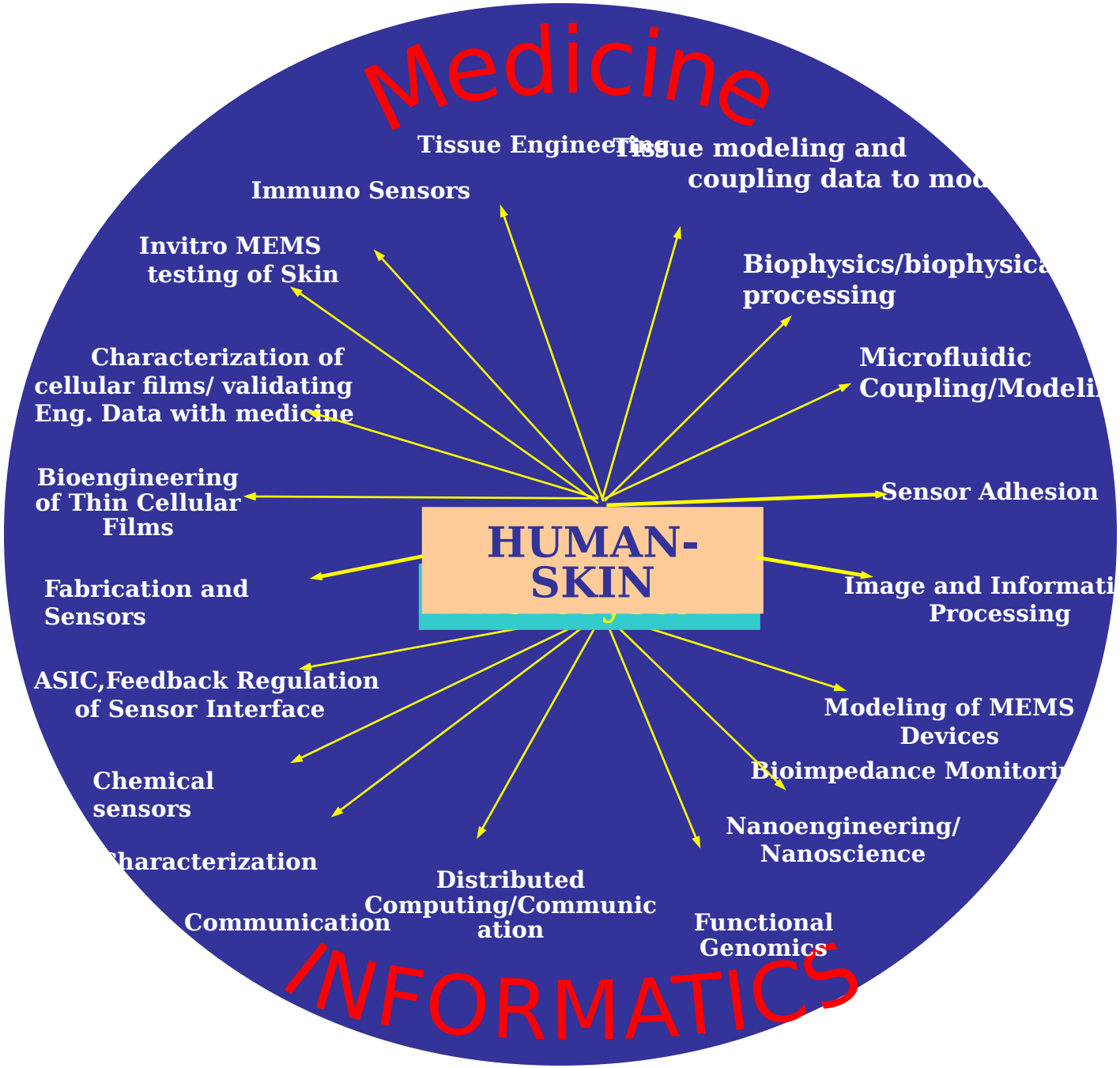
and Nanosystems-Fabrication and Integration

Patient/Warfighter Health Monitoring



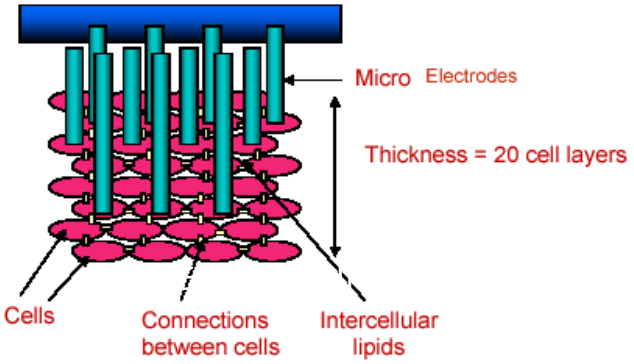


- NSF: Investigate the dynamic, information rich, molecular structure of the ultimate smart interface – *human skin* - by coupling advances in biological, microsystems, nanotechnology and information technology.
- DOD: Warfighter health monitoring

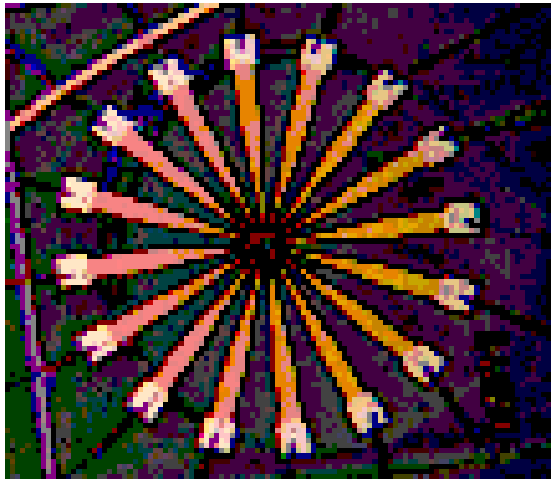

Medicine
Tissue Engineering
Tissue modeling and coupling data to mod
Immuno Sensors
Invitro MEMS testing of Skin
Biophysics/biophysica processing
Characterization of cellular films/ validating Eng. Data with medicine
Microfluidic Coupling/Modeli
Bioengineering of Thin Cellular Films
Sensor Adhesion
HUMAN-SKIN
Fabrication and Sensors
Image and Informati Processing
ASIC,Feedback Regulation of Sensor Interface
Modeling of MEMS Devices
Chemical sensors
Bioimpedance Monitori
Nanoengineering/ Nanoscience
haracterization
Distributed Computing/Communic ation
Communication
Functional Genomics
INFORMATICS

Cell Characterization using Bio-Impedance Techniques

- Design and fabrication of micro-electrode array integrated with fluidic bio-MEMS system



- Build “bio-impedance fingerprint” of cells/molecules/DNA

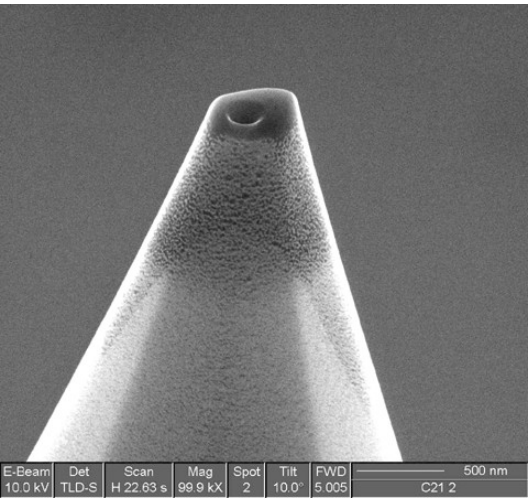


- Develop interface for continuous non-invasive monitoring of tissues/cells

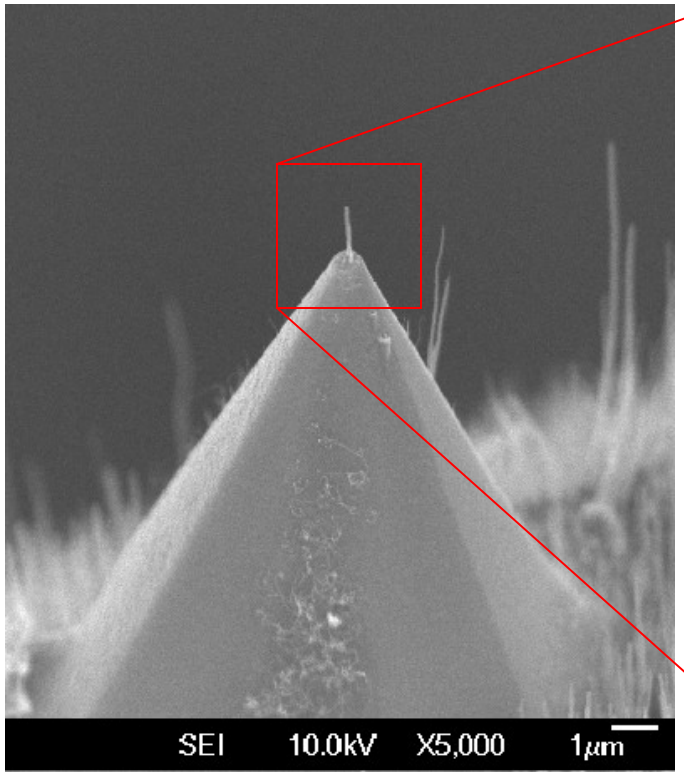
Rudy Schlaf, PhD
Electrical Engineering

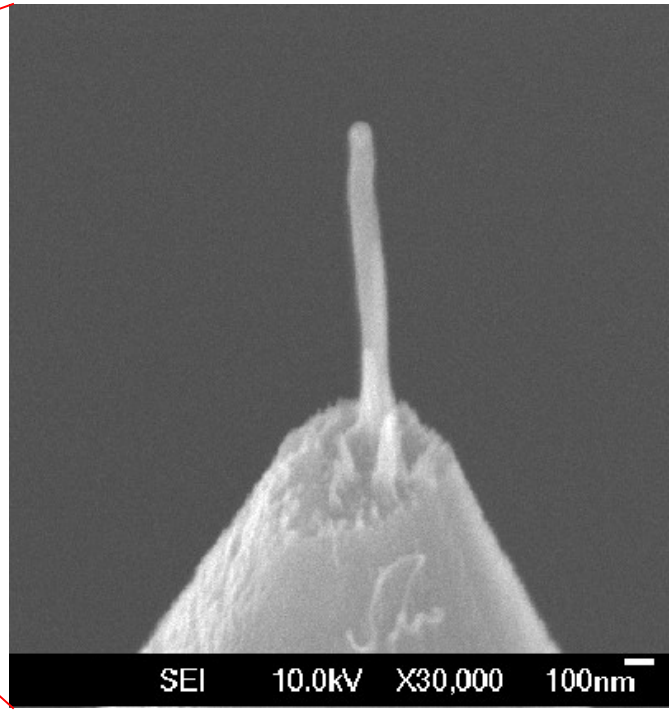
Carbon Nanotubes,
Directed Assembly, Nano-Patterning

Growth of CNT on AFM Cantilevers



After FIB milling





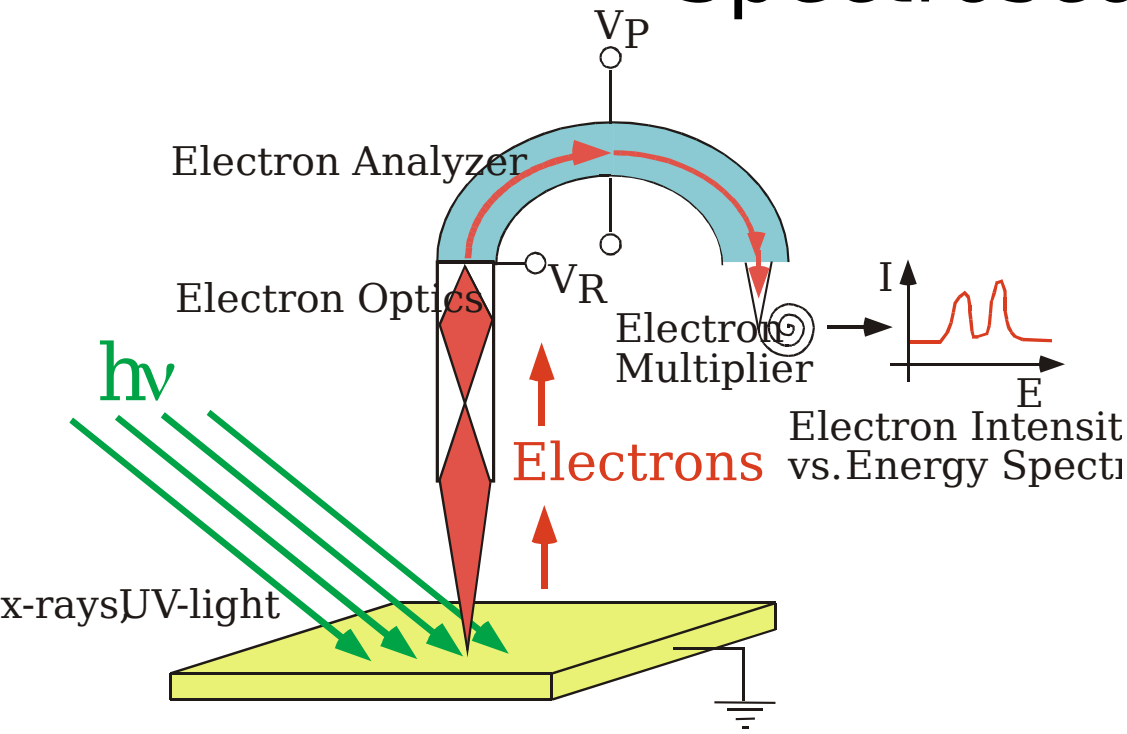
- 100 nm diameter oriented CNT grown in a precisely defined location

Bio/Polymer/Supramolecular Interfaces

- Materials:
  - Polymers
  - Nano-crystals/clusters
  - Biological Molecules
    - DNA, RNA
    - Proteins
  - Supramolecular materials

- These materials are considered building blocs for nano-devices
- Interfaces are crucial for charge transport, adhesion, ordering, self-assembly…
- Special “quantum properties” due to <20 nm sizes

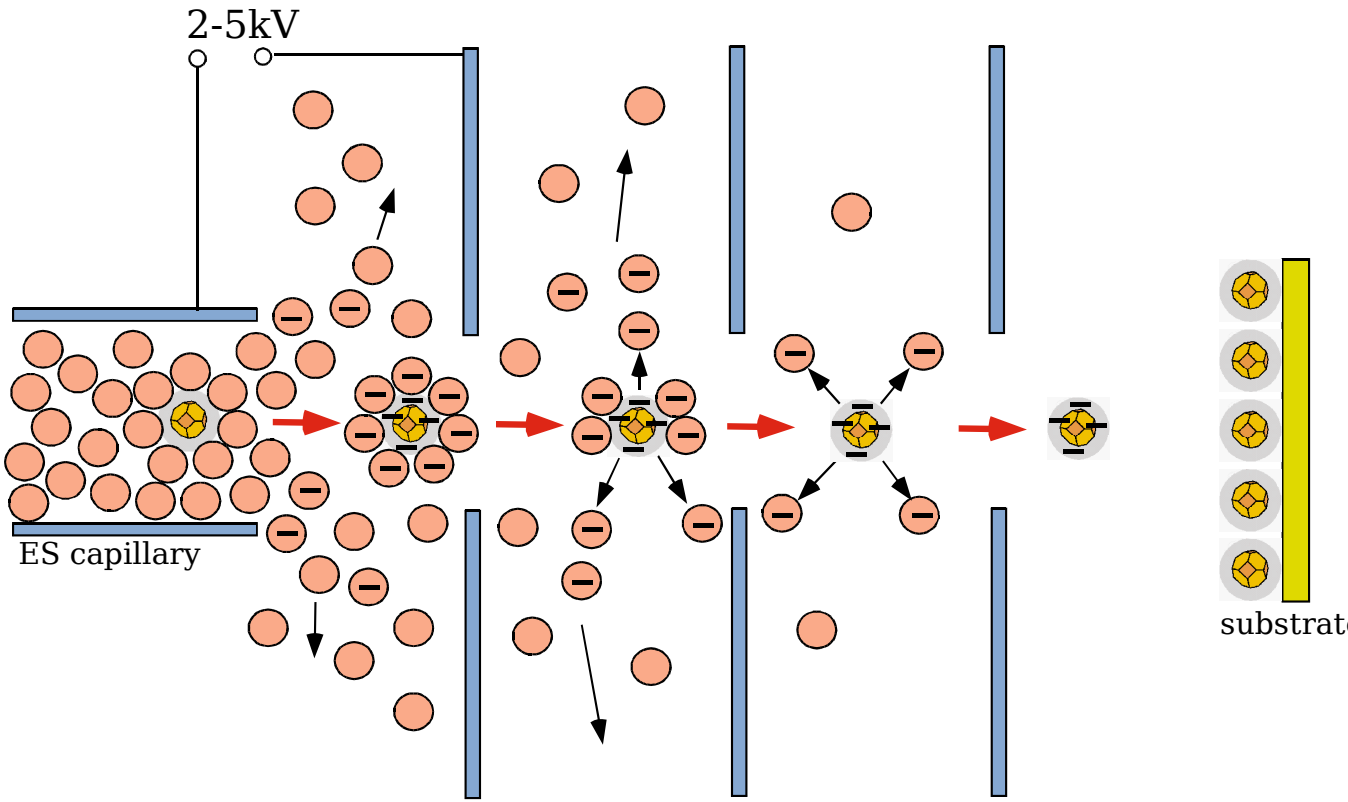
Electronic Structure of Macromolecular Interfaces Determined by Photoemission Spectroscopy



- Photoelectric effect
- X-rays or UV photons excite electrons
- Electron energy is measured
- Information about the density of states (DOS) is obtained

In-Situ Preparation of Macro Molecular Thin Films: Electrospray Injection Directly into High Vacuum

- Proven concept; commercially used in mass spectroscopy of large molecules
- Macro-molecular thin filmscan be deposited in vacuum directly from solution
- Differential pumping stages remove solvent
- Compatible with high vacuum
- Multi layer deposition is possible
- Reduction of intersolubility issues

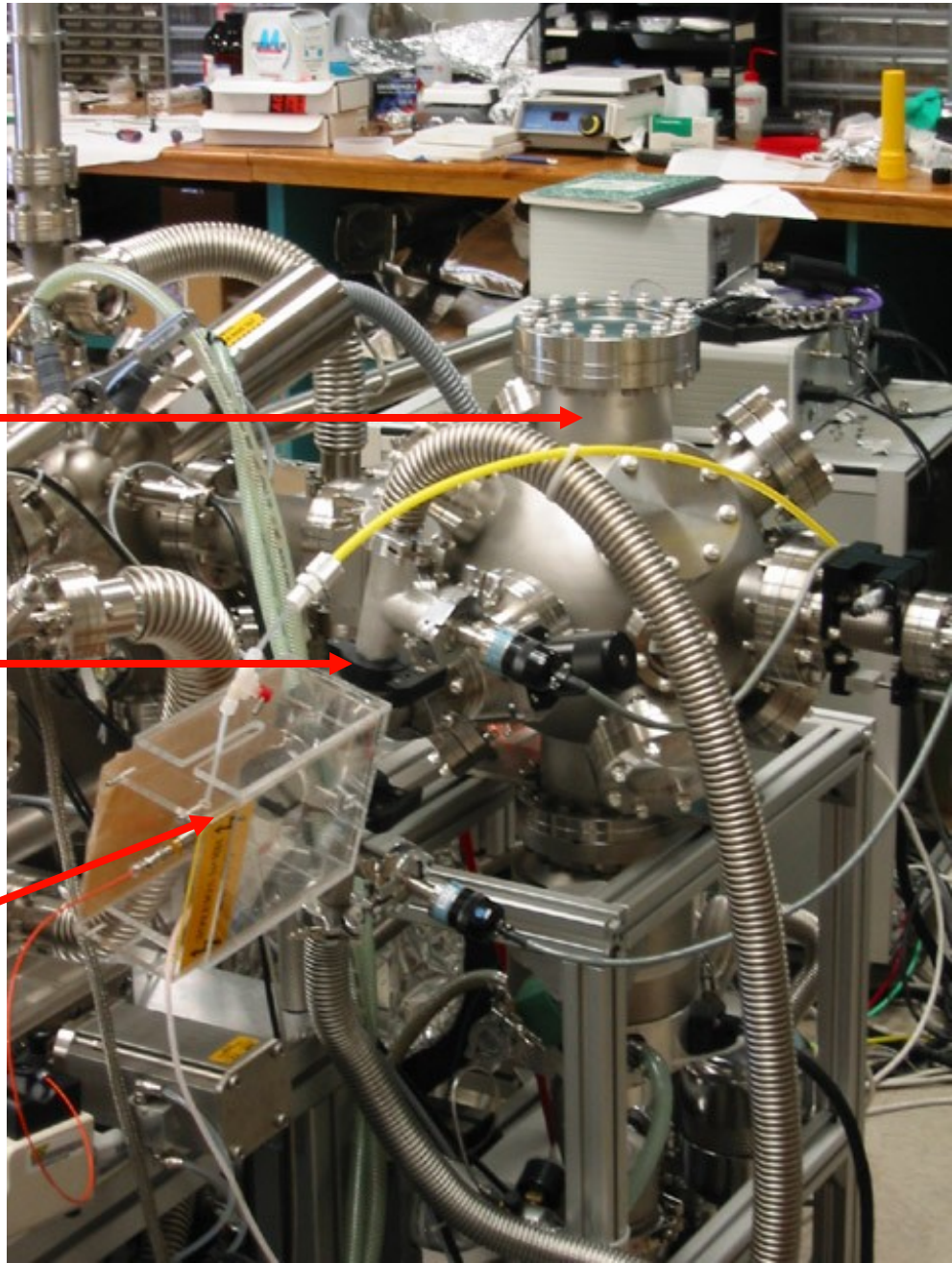


Electrospray System

Deposition chamber

Differential pumping system

Spray head with high voltage shield



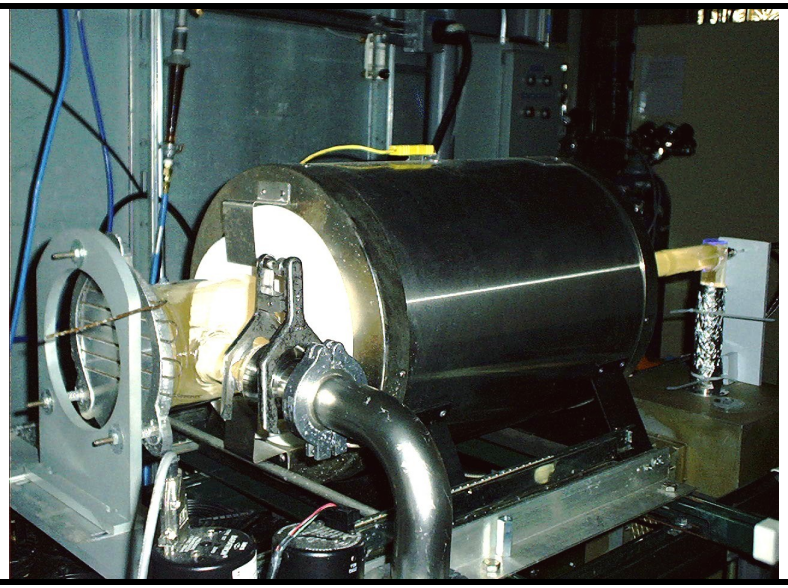
Hoff, Andrew, PhD
Electrical Engineering

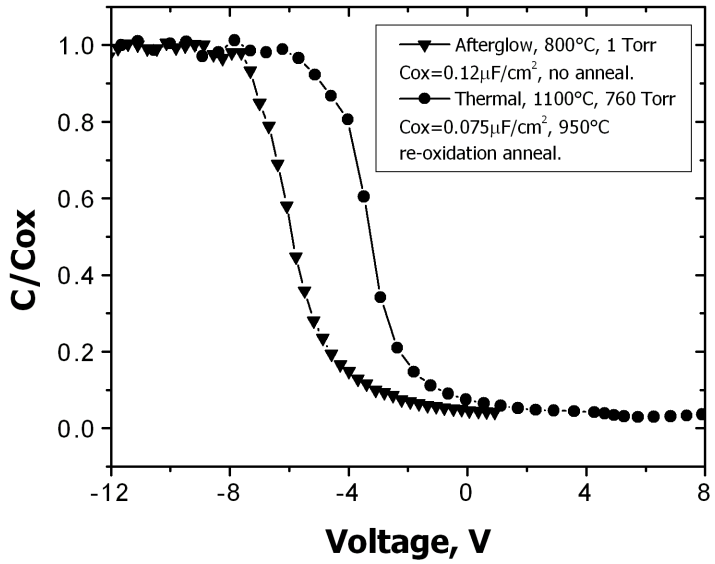
Metrology, Corona Electroporation

SiC Oxidation and Film Metrology

<u>Precompetative Technology:IP, USF</u>

- Oxidation at 1 Torr in the neutral products of an afterglow microwave source.
- Growth rates higher than atmospheric furnace processing over entire temperature range 600C<T<1100C





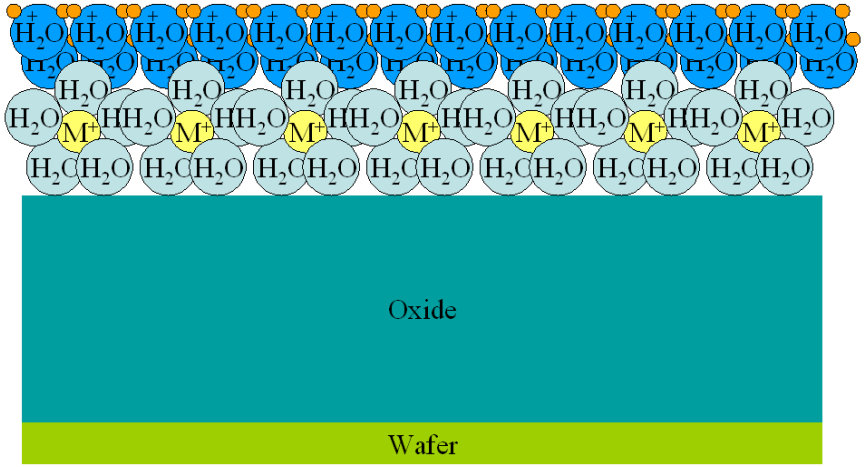
<u>Technology Opportunities</u>

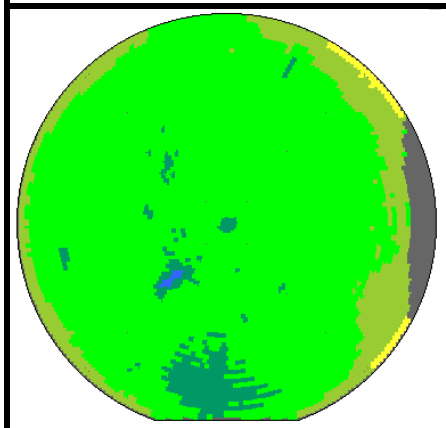
- Improved interfacial properties.
- Pathway to integrated processing and film improvements via ag. tech.
- Preliminary results on unpolished 3C comparable to SiO_2 on Si.
- SOC, smart power, smart sensors

Corona assisted auto assembly

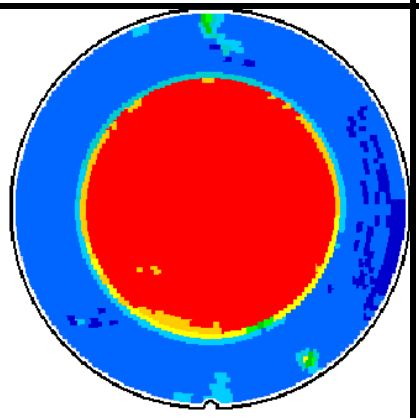
Precompetative Technology:no IP

- Method of selectively locating impurities, metals, tracers in materials at levels below surface analysis sensitivity.





Uniform Na



Patterned
$\Delta \sim 10^2$

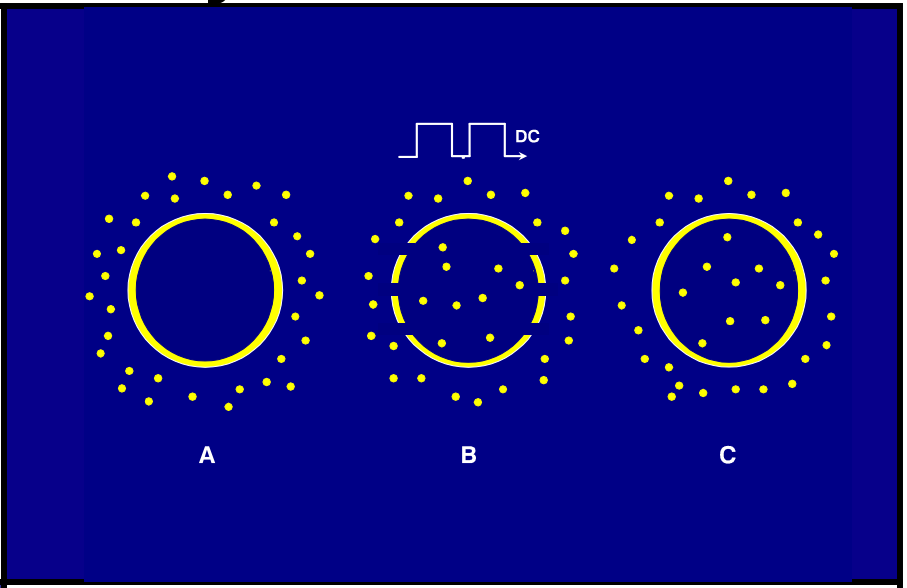
Technology Opportunities

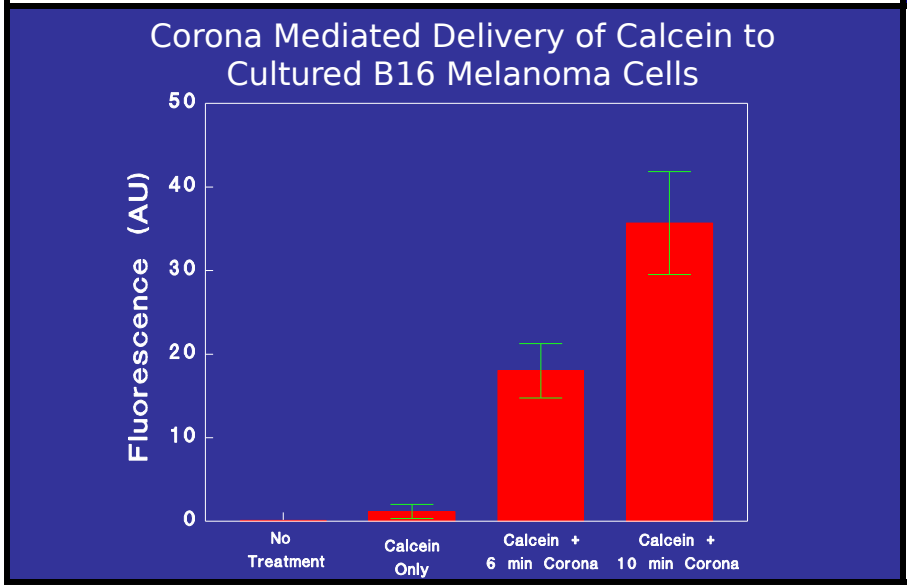
- Undetectable labels.
- $10^9 cm^{-2}$<surface conc.<$10^{13} cm^{-2}$.
- Two orders of magnitude Δ so far.
- May be applied where inter-diffusion possible, s.a. oxide, polymer, fabric, metal.

Molecular Delivery to Cells

<u>Precompetative Technology:IP, USF</u>

- Collaboration /w M. Jaroszeski (ChE), Med. School, Ctr. For Mol. Delivery.
- Non-contact electroporation of cells using corona charge applied from remote ion source.





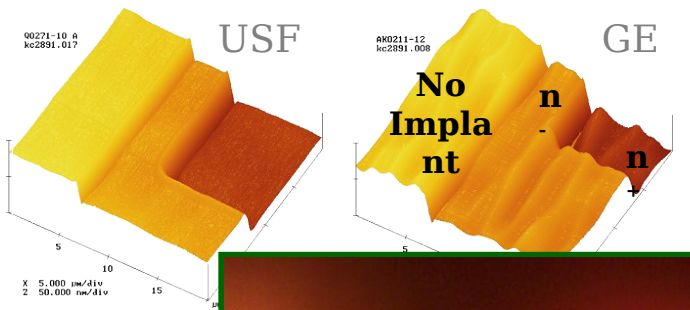
<u>Technology Opportunities</u>

- Electrode-less treatment of cancer and other diseases.
- Possible incorporation of plasmid DNA into tissue.
- Field administered anti-shock/toxic mediation therapies.

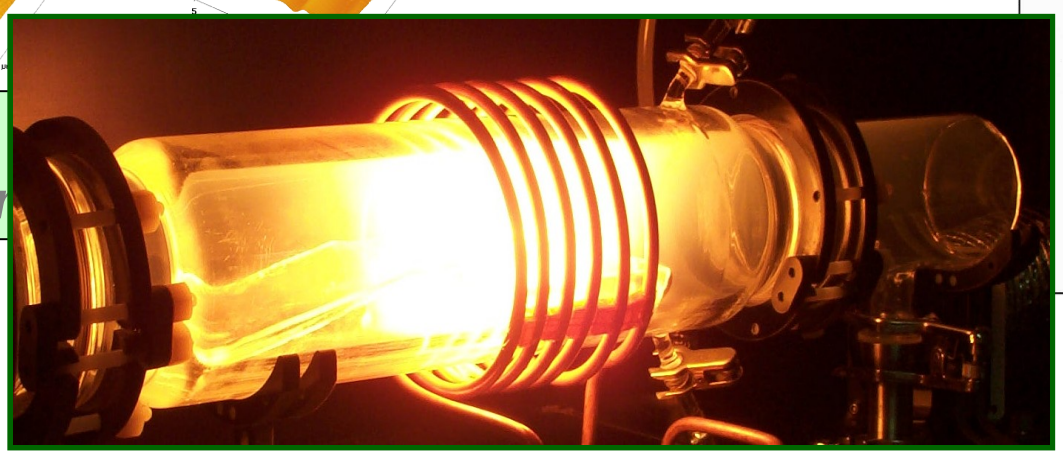
Steve Saddow, PhD
Electrical Engineering

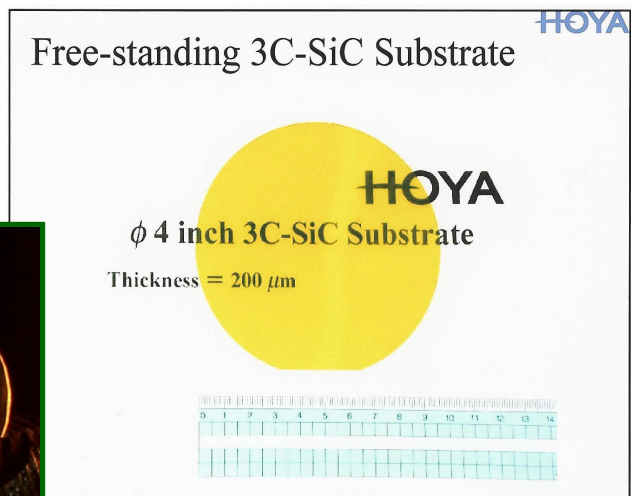
SiC Nanotemplates, SiC devices, and Quantum Dots

SiC Materials Processing is *the Key* to Many Applications



USF IA GE Co





USF Epi growth on 3C, 4H, 6H and Si!

- **Applications include electronics, bio/chem sensors, MEMS, tissue engineering, etc.**
  - **High temp electronics for electric vehicle applications (κ = value for Cu at RT!)**
  - **Strong bonding for chemical inertness/robustness (no wet etch**

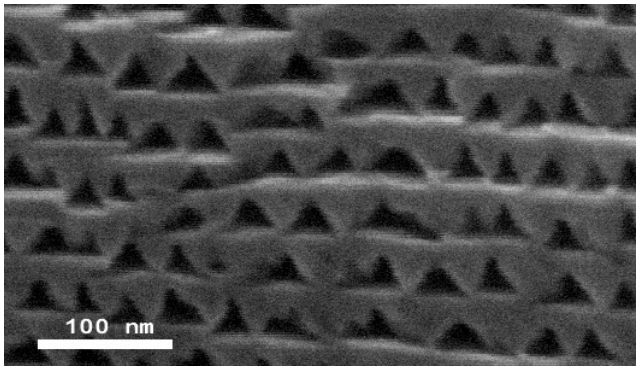
USF SiC Group is one of only a handful of university of full-spectrum SiC processing…from epi to device fa

John Wolan, PhD
Chemical Engineering

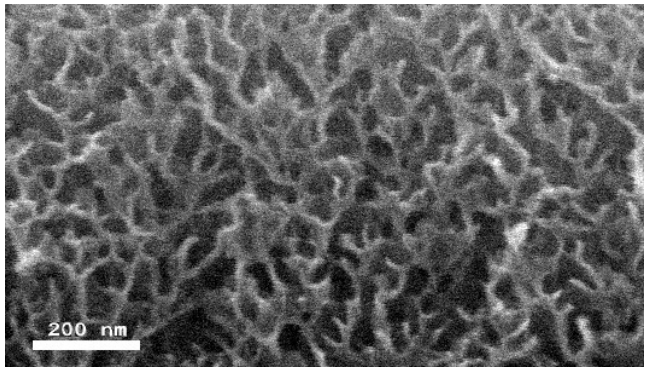
Surface Science,
Reaction Engineering,
Wide Bandgap Materials

SEM Micrographs of Porous SiC in n-type 4H/6H SiC

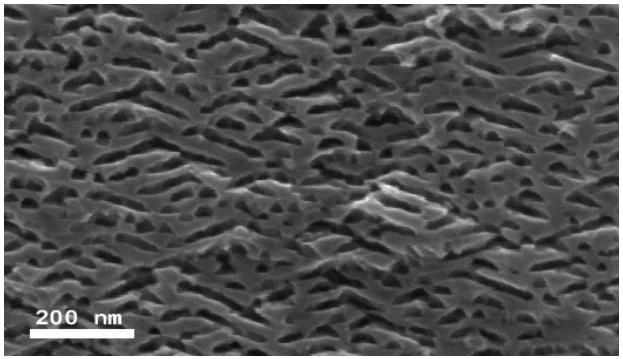
x-section



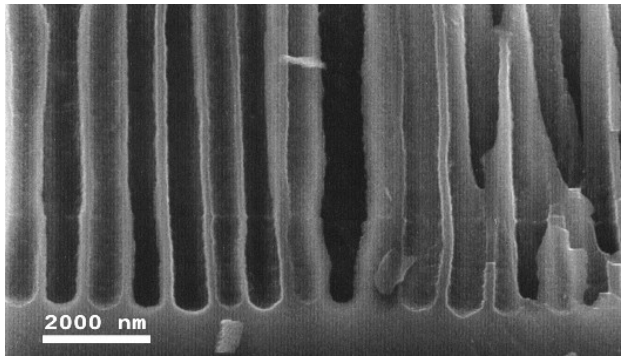
Triangular/planar structure



Algae morphology



Chevron structure



Asparagus structure

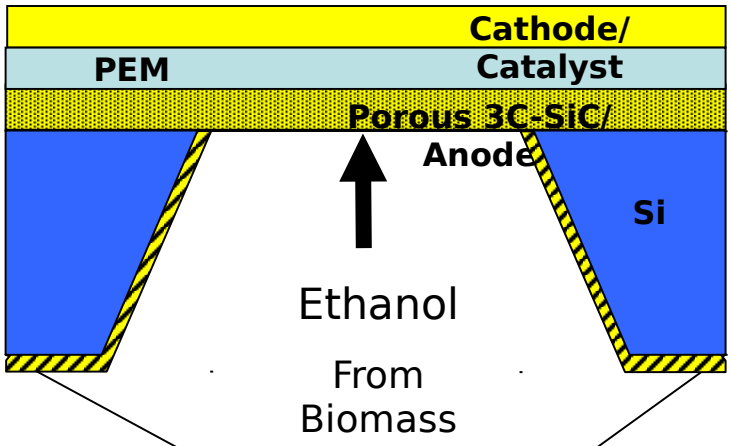
DURINT Research Grant awarded by the Office of Naval Research
Research work with Dr.s W.J. Choyke and R.P. Devaty, U. Pitt Physics Dept.

Porous 3C-SiC DEFC Fuel Cell Design

$8H+(aq) + 8e- + 2O_2(g) \rightarrow 4H_2O(l)$

Air

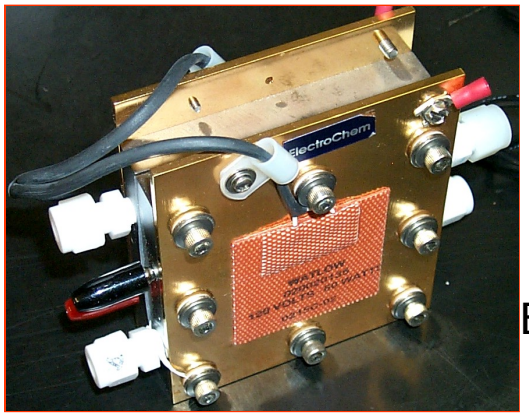
Proton exchange membrane

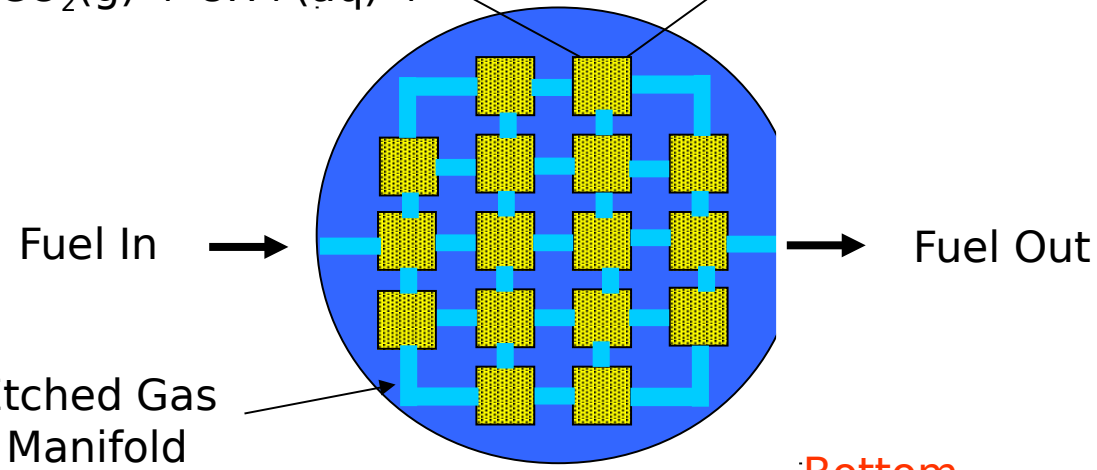


X-Section

Si IC wafer scale-up

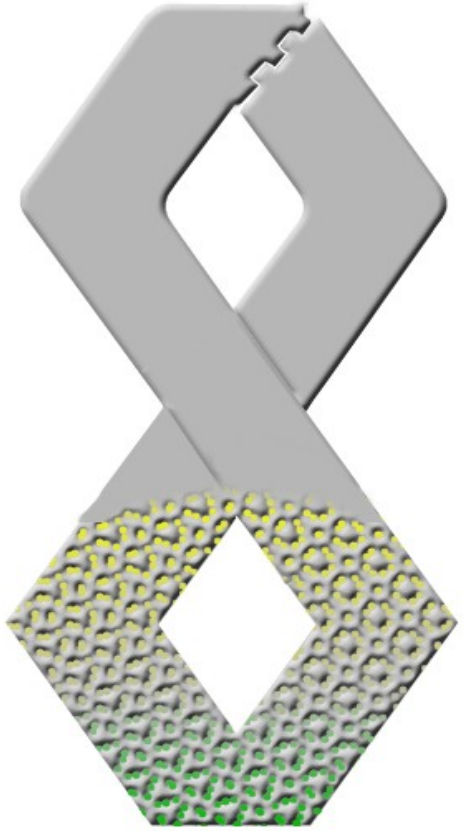
$C_2H_5OH(aq) + H_2O(aq) \rightarrow 2CO_2(g) + 8H+(aq) + 8e-$





Bottom View

Nanomaterials and Nanomanufacturing Research Center, NNRC



- NNRC Capabilities
  - People
  - Facilities
- Research Examples
- NNIN, National Nanotechnology Infrastructure Network

Topics

- USF: National / Regional Context
- USF Assets Related to Objectives of 2003 USSOCOM CBRN Conference
- Overview of Selected Research in Nanomatereials and Nanomanufacturing at USF

Update:Nanomaterials and Nanomanufacturing Center, University of South Florida

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USSOCOM Chemical, Biological, Radiological and Nuclear Conference and Exhibition

December 1-4, 2003